

# Brookhaven Linac Isotope Producer

## Facility Environmental Monitoring Report

Calendar Year 2003



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#### ***Summary of Results***

*During 2003, tritium concentrations increased in wells 40 feet downgradient of the BLIP target vessel, reaching a maximum of 42,900 pCi/L in October. Tritium concentrations declined to less than the 20,000 pCi/L drinking water standard by November 2003. An inspection of the BLIP facility found the gunite cap, the paved areas and the roof drains to be in good condition and effectively controlling stormwater infiltration. A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations may be correlated to a 6.5 foot increase in water table elevation that occurred between November 2002 and July 2003. As the water table rose, older tritium that was leached from the activated soils prior to capping in 1987 and from the grout injection project may have been flushed from the soils close to the water table.*

*The BLIP facility operated over a 16-week period. The major radionuclide emissions consisted of carbon-11 and oxygen-15, with small amounts of tritium. The amount of C-11 and O-15 emitted from the facility was estimated to be 934 curies, and 2,782 curies, respectively. The radioactive gases have short half-life: 20.48 minutes for C-11 and 122 seconds for O-15, and mainly contribute to immersion external dose. A Tritiated vapor emission for the calendar year was 1.7 E-02 curies. The effective dose equivalent to the maximally exposed individual was calculated to be 5.96 E-2 mrem for the calendar year.*

#### **Background**

When the BLIP is operating, the Linear Accelerator (Linac) delivers a 200-MeV beam of protons that impinge on a series of targets within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot deep underground tank, inside a water-filled 18-inch diameter shaft that runs the depth of the tank. The targets are cooled by a 500-gallon closed-loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and the soils immediately outside of the tank are activated due to the creation of secondary particles produced at the target. Air emissions from the BLIP facility pass through a HEPA filtration system. Following filtration, only the short-lived gases radionuclides, such as C-11, O-15 and tritium are released to the atmosphere.

In a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements and is registered with the Suffolk County

Department of Health Services (SCDHS). The BLIP facility also has a 500-gallon capacity underground storage tank for liquid radioactive waste (change-out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L were detected in groundwater downgradient of BLIP. Due to the impact to groundwater quality, the BLIP facility was designated Area of Concern (AOC) 16K under the Environmental Restoration program.

Following the detection of tritium in groundwater, BNL improved the stormwater management program at the BLIP to prevent rainwater infiltration of the activated soils below the building. The BLIP building's roof drains were redirected away from the building, paved areas were resealed, and a gunite (cement) cap was installed on three sides of the building. In May–June 2000, the BNL Environmental Restoration program installed an additional protective measure with the injecting of colloidal silica grout, referred to as a Viscous Liquid Barrier (VLB), into the activated soils. The grout reduces the permeability of the soils, thus further reducing the ability of rainwater to leach radionuclides should the primary stormwater controls fail.

## Environmental Monitoring Program

As required by DOE Order 450.1, BNL has established an environmental monitoring program at the BLIP facility to evaluate potential impacts to environmental quality from its operation, and to demonstrate compliance with DOE requirements and applicable federal, state, and local laws and regulations. This program is fully described in the *BNL Environmental Monitoring Plan* (BNL, 2003). The monitoring program components are summarized below.

## Monitoring Results

### Groundwater

Groundwater quality at BLIP is monitored using two upgradient and five downgradient wells. The locations of monitoring wells are shown in Figure 1.

As described in previous reports, a short-term increase in tritium concentrations was detected in BLIP area monitoring wells following the May-June 2000 injection of the VLB grout. Tritium concentrations increased from nearly non-detectable levels prior to the grout injection to 56,500 pCi/L in October 2000. An investigation determined that the grout had displaced a small volume of tritiated soil pore water. Some of this displaced water entered the aquifer below the BLIP building. Tritium concentrations decreased to <20,000 pCi/L by the end of December 2000, and remained at these levels through 2001 and 2002 (Figures 2 and 3).

In January 2003 tritium concentrations once again exceeded the 20,000 pCi/L standard in wells immediately downgradient of BLIP, with a concentration of 27,700 pCi/L detected in well 064-67. Tritium concentrations remained above 20,000 pCi/L throughout most of the year, reaching a maximum of 42,900 pCi/L in October (Figure 2). Tritium concentrations declined to less than 20,000 pCi/L by November 2003. Sodium-22 concentrations increased to a maximum of 185 pCi/L, well below the 400 pCi/L standard.

In accordance with the BNL Groundwater Protection Contingency Plan, BNL notified the regulatory agencies of this situation, increased the groundwater sampling frequency from quarterly (12 week periods) to every six-weeks, and formed a technical team to review the condition and adequacy of current stormwater controls. An inspection of the BLIP facility found the gunite cap, the paved areas and the roof drains to be in good condition and effectively controlling stormwater infiltration (Figure 4). Although direct inspection of the VLB grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations may be correlated to a 6.5 foot increase in water table elevation that occurred between November 2002 and July 2003 (Figure 5). As the water table rose, older tritium that was leached from the activated soils prior to capping in 1987 and from the grout injection project may have been flushed from the vadose zone soils close to the water table. Figure 6 provides a pictorial view of this process. It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay. As an added measure of protection, the Medical Department and Collider-Accelerator Department will be constructing new protective caps over the Linac to BLIP spur and the Linac to Booster transition, respectively (Figure 7). Direct soil measurements and beam loss calculations suggest that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the "5%" criteria described in the Accelerator Safety Subject Area.<sup>1</sup> This integrated cap system will join the existing BLIP and Booster caps.

### **Air Monitoring**

Emissions from the BLIP facility pass through a HEPA and charcoal filtration system before being released through a 16-meter stack. Air samples are continuously collected after the HEPA and charcoal filtration system to monitor the emissions. Particulates are collected on a glass fiber filter for gamma analyses, a TEDA-loaded charcoal cartridge is used for radioiodines, and tritiated water vapors are collected with silica gel. Radiological gases emissions, such as oxygen-15 and carbon-11, are estimated using an emission factor that is based on hours of operation and the beam intensity received on the targets (i.e., mCi/micro-ampere-hrs). Additionally, the radioactive gas emissions were characterized with an inline sampling and positron detection system. The short-lived

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<sup>1</sup> The BNL Accelerator Safety Subject Area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed 5 percent of the drinking water standard (i.e., >1,000 pCi/L for tritium and 20 pCi/L for sodium-22).

gases concentrations measured by the NaI gamma detection system were used in estimating the source term to the environment, and for dose calculations to members of the public.

In CY 2003, the BLIP facility operated over a 16-week period. The major contributors to emissions were carbon-11 and oxygen-15, with small amounts of tritium. The average source term for C-11 was estimated at 934 curies, and O-15 was estimated at 2,782 curies. Carbon-11 and O-15 have short half-lives of 20.48 minutes and 122 seconds, respectively, and mostly contribute to immersion external dose. Tritiated vapor emissions for the calendar year 2003 were measured to be  $1.7\text{E-}02$  curies. The effective dose equivalent to the maximally exposed individual was calculated to be  $5.96\text{E-}2$  mrem for the calendar year.

The facility emissions were below DOE's derived concentration guide limits for the members of the public, and well below EPA's air dose limit of 10 mrem in a year. Therefore, it can be safely concluded that there was minimal impact to the environment and the public from BLIP operations.

Although there was a decrease in total emissions in 2003, further reductions are being pursued. Because humidity from the hot cell's cooling water is the primary source of emissions, in January 2003 a shroud seal was installed to enclose the cooling water surface (16-inch diameter shaft), target holder transfer cases, chain drive assembly, (including motor supports), and any other associated appurtenances (Figure 8). The shroud seal engineering control is expected to reduce gaseous emissions from the BLIP facility by approximately 28 percent.

On January 30, 2003, the US Environmental Protection Agency, Office of Radiation and Indoor Air, Radiation Protection Division visited BNL to conduct an inspection of the BLIP facility. There were no compliance issues identified during the inspections that required corrective action. EPA requested and received documents related to emissions modeling. Efficiency testing of the shroud seal could not be satisfactorily completed in 2003 because the BLIP run time was short (16 weeks), beam power/ energy was not stable, and due to questionable detector calibration. Efficiency testing will be conducted in early 2004.

## Future Monitoring Actions

Monitoring activities for CY 2004 will include:

- Groundwater samples will be collected quarterly, and analyzed primarily for tritium. Particular wells immediately downgradient of the BLIP may also be periodically tested for sodium-22. If tritium concentrations are continually less than the 20,000 pCi/L drinking water standard by the end of 2004, consideration will be given to reducing the sampling frequency to semiannually, starting in 2005.

- The continuous monitoring for particulates, radioiodines, and tritium will be kept the same, that is, weekly collection and analysis of filters/silica gel along with timely verification and validation of the analysis results.
- Sampling and monitoring for the short-lived gases will continue during the facility operation until the efficiency of the shroud has been thoroughly tested, and emissions verified. The Environmental Protection Agency will be notified of the test results and future actions taken to keep the effective dose equivalent to member of the public below one percent of the NESHAPs standard.

## References

BNL, 2003. *Brookhaven National Laboratory Environmental Monitoring Plan, CY 2003 Update (January 2003)*. BNL-52676.

**Table 1. BLIP Facility Summary of Tritium and Sodium-22 Results, CY 2003.** Wells 64-46 and 54-61 are upgradient of the BLIP. Wells 64-47, 64-48, and 64-67 are approximately 40 feet downgradient, and wells 64-49 and 64-50 are approximately 150 feet downgradient.

Well	Radionuclide	01-27-03	03-12-03	04-3/4-03	05-21-03	07-14-03	09-04-03	10-06-03	11-05-03
----- (pCi/L) -----									
64-46	Tritium	<320	<352	<313	NS	<303	NS	NS	NS
	Sodium-22	NA	ND	NA		NA			
54-61	Tritium	<320	NS	<313	NS	NS	NS	NS	NS
	Sodium-22	NA		NA					
64-47	Tritium	348 +/- 205	NS	<346	NS	<1,100 +/- 257	1,010 +/- 274	1,230 +/- 257	489 +/- 210
	Sodium-22	NA		2.4 +/- 1.3		NA	5.1 +/- 1.9	3.4 +/- 1.3	NA
64-48	Tritium	3,740 +/- 338	NS	3,440 +/- 400	NS	27,800 +/- 808	28,500 +/- 909	42,900 +/- 988	15,500 +/- 591
	Sodium-22	NA		13.7 +/- 2.1		NA	43.7 +/- 4.4	47.3 +/- 3.8	NA
64-67	Tritium	27,700 +/- 788	23,600 +/- 907	37,800 +/- 1,070	30,300 +/- 977	16,400 +/- 631	11,400 +/- 601	5,460 +/- 397	4,550 +/- 356
	Sodium-22	NA		53.6 +/- 4.9	185 +/- 15.8	NA	168 +/- 11.4	165 +/- 12.2	NA
64-49	Tritium	<320	NS	<313	NS	NS	NS	<299	NS
	Sodium-22	NA		NA				NA	
64-50	Tritium	4,830 +/- 367	NS	4,480 +/- 451	NS	3,720 +/- 352	NS	3,150 +/- 329	NS
	Sodium-22	NA		NA		NA		NA	

## Notes:

Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

NA = Not analyzed for this radionuclide.

ND = Radionuclide not detected.

NS = Well not sampled during this period.

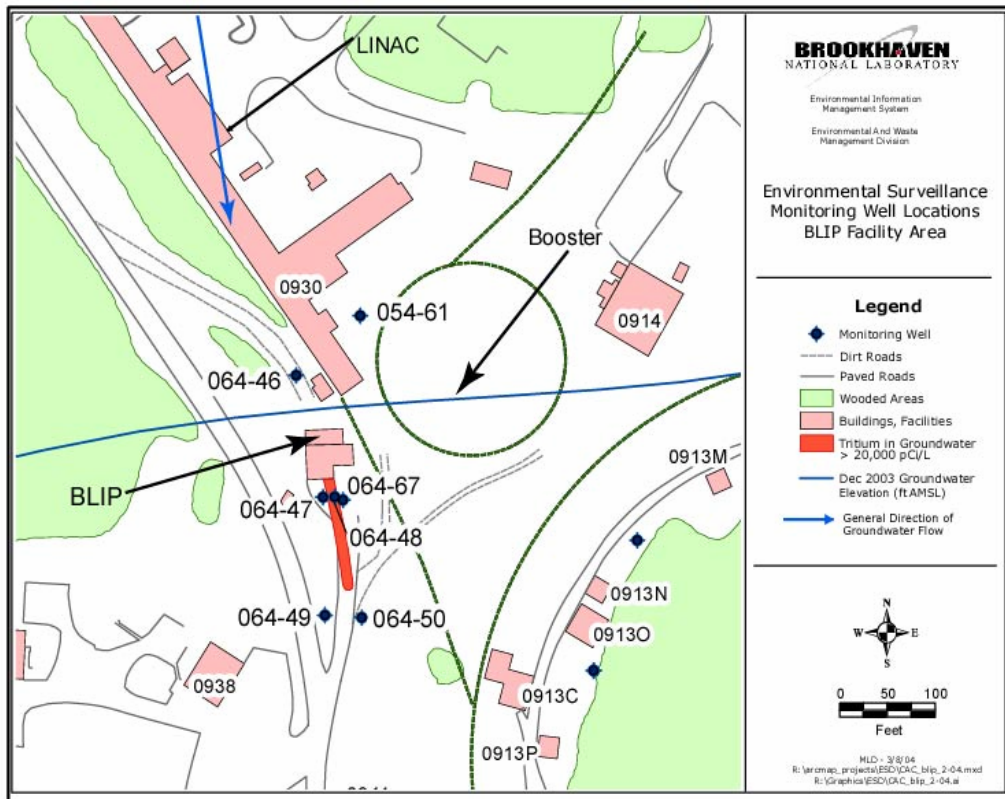


Figure 1. Monitoring Well Locations Near the BLIP Facility at BNL.

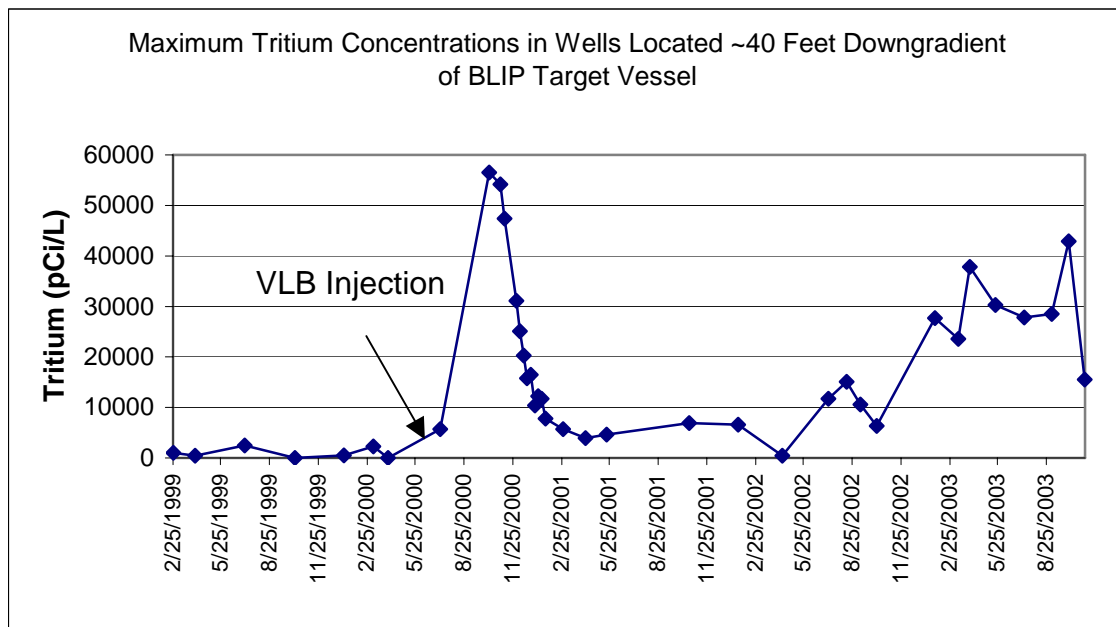


Figure 2. Tritium Concentration Trends 40 Feet Downgradient of the BLIP, CY 1999–2003.



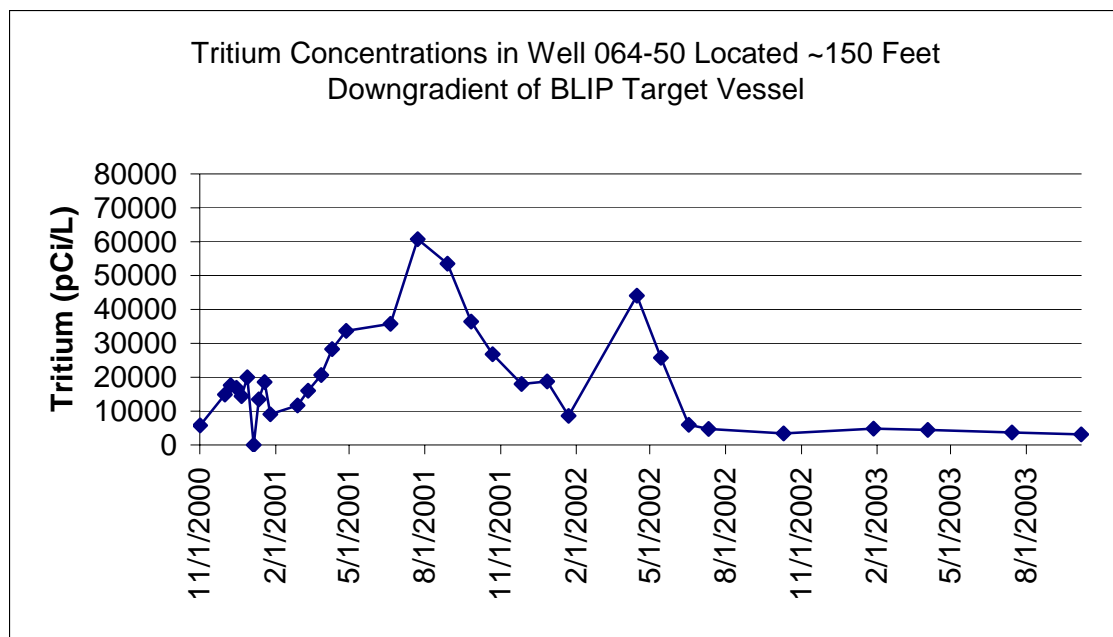


Figure 3. Tritium Concentration Trends 150 Feet Downgradient of the BLIP, CY 2000–2003.



Figure 4: Paved area on south side of BLIP Building, and three downgradient monitoring wells (orange caps).

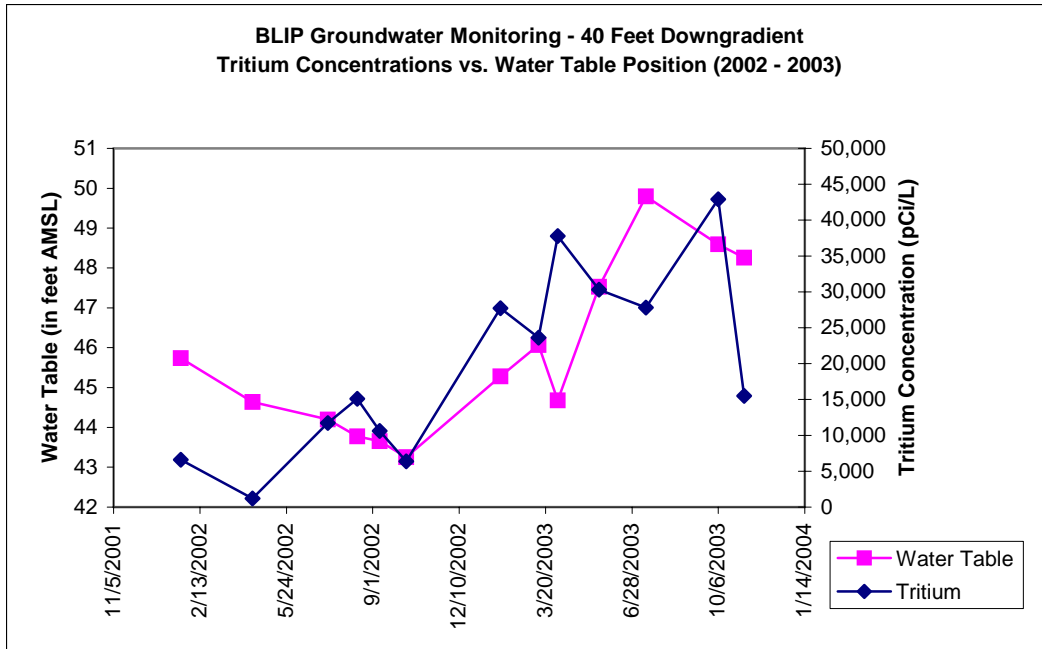


Figure 5: Comparison of tritium concentrations and water table fluctuations

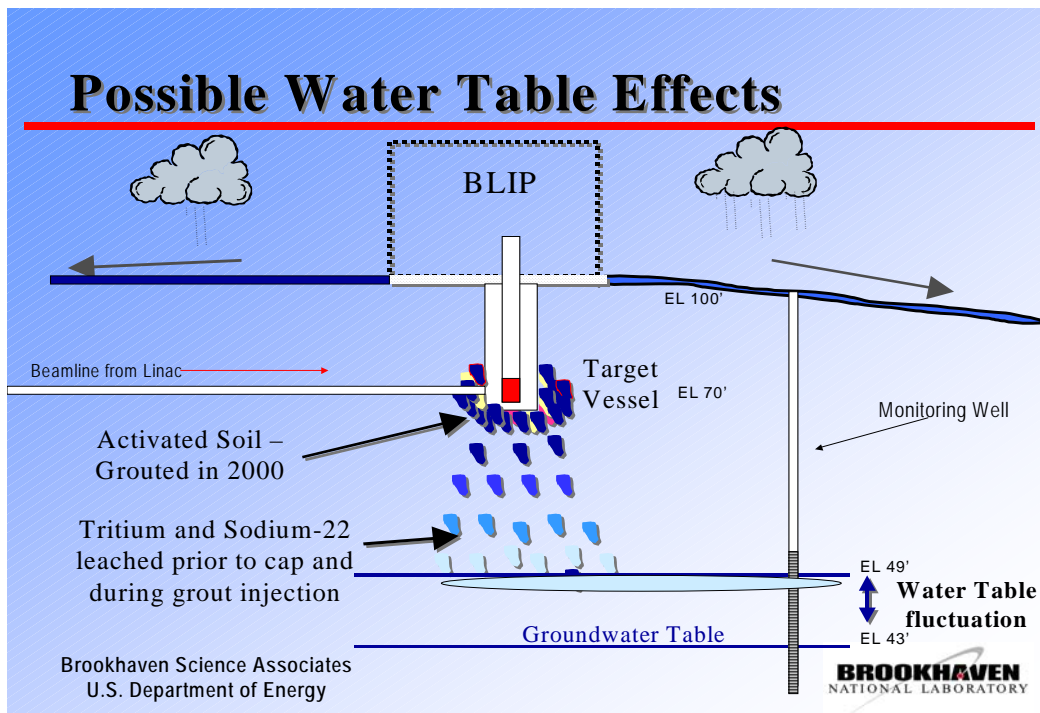


Figure 6. Possible water table fluctuation effects on the release of tritium from the vadose zone.



Figure 7. Planned installation of new caps for improved stormwater management in the BLIP, Linac and Booster areas.



Figure 8. BLIP hot cell with new shroud.